Photon Detection using the STAR Time Projection Chamber

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Photons are produced in all stages of heavy ion collisions. In contrast to hadrons which have large interaction cross sections and short interaction lengths, photons are expected to have a mean free path of ~30fm in hadronic matter. Therefore, many of the photons produced in the initial phase of the collision will escape from the system. These photons provide a microscopic probe of the early stages.

One method of measuring photon production in the energy range of 50 MeV - 4 GeV is through e^+e^- pair creation in the field of a nucleus. The STAR Time Projection Chamber (TPC)[1] has been used to detect these pairs and hence the photon energy. This approach has advantages and disadvantages in comparison to measurements through electromagnetic calorimeters. The advantages are better energy resolution, directional resolution, purity, and detection capabilities at lower energies. These advantages compensate for disadvantages like low efficiency, which is approximately ~1% or about two orders of magnitude below the typical calorimeter.

Photon candidates are found by searching for pairs of tracks originating from secondary vertices. The pairs are required to have the geometric signatures of a conversion, like a small opening angle. In theory the average conversion opening angle is about a tenth of a degree. Once good photon candidates are chosen, event dependent cuts are made to select primary photon candidates. Directional resolution and distance of closest approach to the primary vertex cuts are among the primary photon cuts. The angular resolution is experimentally extracted by comparing the reconstructed photon momentum direction with the expected direction obtained from the conversion position. From this, the derived angular resolution is about 1 degree, as shown in Fig. 1. This angular precision results in a few centimeter vertex resolution.

We have measured an uncorrected photon transverse energy distribution and reconstructed π^0's via the $\gamma\gamma$ decay channel. We have also mapped out the detector material with the conversion vertices. An accurate material lay out is important for event generators to correctly reproduce material effects like multiple scattering

Footnotes and References

[1]J.Harris,(STAR Collaboration) *'Quark Matter 2001 Proceedings', Stony Brook, January 15-20, 2001, F. Retiere, (STAR Collaboration) 'Quark Matter 2001 Proceedings', Stony Brook, January 15-20, 2001.*

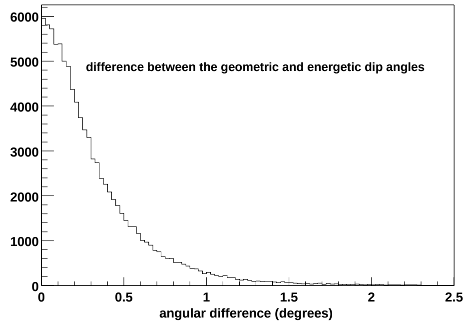

Figure 1: *The difference between the momentum and conversion point angle is a measure of reconstruction angular resolution. This resolutions extrapolates to a few centemter vertex resolution.*

and energy loss of detected particles.

The first results tested the well known theory of pair production. The energy shared between the electron and positron in a photon conversion above a few hundred MeV/c^2, is a symmetric probability distribution that has a minimum at $E_{e^-}/E_\gamma = 0.5$ [2]. The energy sharing distribution extracted from the data agrees with the theoretical distribution in regions where the efficiency is flat (Fig. 2). In the region of $E_{e^-}/E_\gamma < 0.25$ and $E_{e^-}/E_\gamma > 0.75$, tracking inefficiency at low transverse momentum is the main cause of the discrepancy between the theory and data.

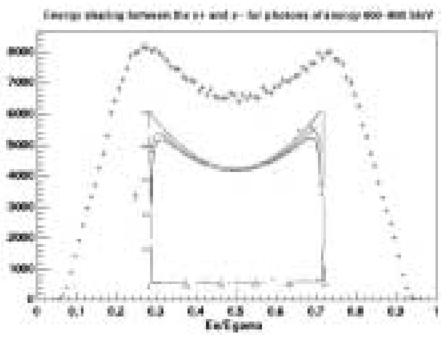

Figure 2: *The energy sharing between the electron and positron in photon conversion is shown in the main plot. The respective theoretical probability distribution is shown in the inlay[2]. The efficiency is flat when the energy ratio, E_{e^-}/E_γ, is between 0.25 and 0.75.*

Footnotes and References

[2]D.H.Perkins, *Introduction to High Energy Physics*, (Addison-Wesley, Reading, 1972) Pg. 86.